44. Some Notes upon the Anatomy of *Rana tigrina*. By Geo. E. Nicholls, D.Sc., late Professor of Biology, Agra College, India *.

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(Text-figures 1–3.)

In several skeletal and other characters, *Rana tigrina*—the so-called Bull-frog of India—differs markedly from our common European grass or water frogs (*R. temporaria*, *R. esculenta*). These two frogs, which resemble one another fairly closely, appear to be the only species of which a detailed description has been given, and figures of one or the other alone appear in text-books all the world over. For the Indian form these figures are in some respects quite misleading, and since this frog is now generally used throughout India as a laboratory type, it has seemed desirable that attention should be called to those features in which *R. tigrina* differs from its European congeners.

1. *The Vertebral Column.*

In correspondence, doubtless, with the much larger size of this frog, the vertebræ are distinctly more stoutly built than is the case in *R. temporaria*. The neural arches are, relatively, greatly developed antero-posteriorly. Thus, when viewed from above, the vertebral column of this species does *not* show a series of gaps between the arches such as is so clearly seen in *R. temporaria* (*cf.* Howes, '02, fig. 35). On the contrary, there is, in *R. tigrina*, a very marked overlap of each arch dorsally upon that immediately posterior to it, and accordingly, when the vertebræ are in position (text-fig. 1), the centra are not visible from above.

Such a condition as this is said to be *imbricate*, and to characterize the Discoglossidæ and Pelobatidæ (Boulenger, '97, p. 38). Concerning the European species of Ranidæ, Boulenger points out that precisely the opposite condition prevails. His statement may be quoted :—"The neural arch is either closed above . . . or notched between the zygapophyses so as to expose the spinal cord between every two vertebræ; the latter type is most marked in *Rana*, in which, the lateral openings for the exit of the spinal nerves being also of large size, the vertebral column forms an open-work above and on the sides."

While this "open-work" vertebral column is seen typically in the European Ranidæ, it is also found in most of the other Anura, so that Boulenger notes this as one of the characters which separate the Bufonidæ and Hylidæ from the more generalized Arcifera. In this imbricate condition of the

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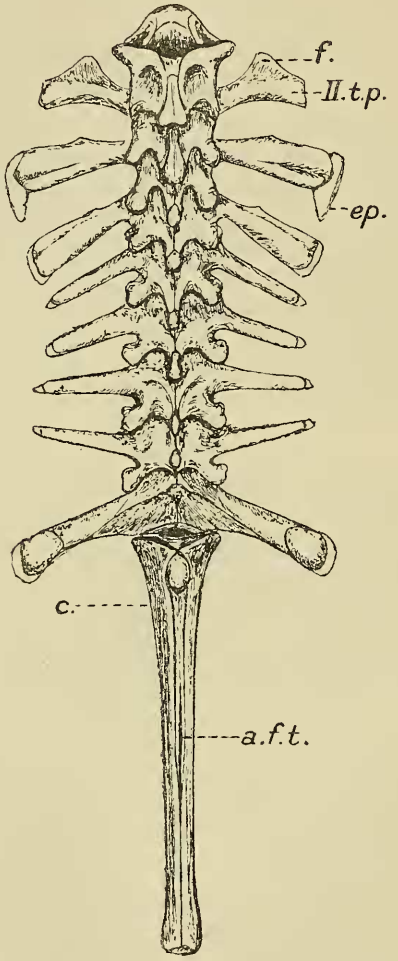
vertebral column it would appear, then, that *Rana tigrina* has retained (or reverted to) a somewhat primitive condition.

Text-figure 1.



The vertebral column of *Rana tigrina*, as seen from above. × $\frac{3}{2}$.

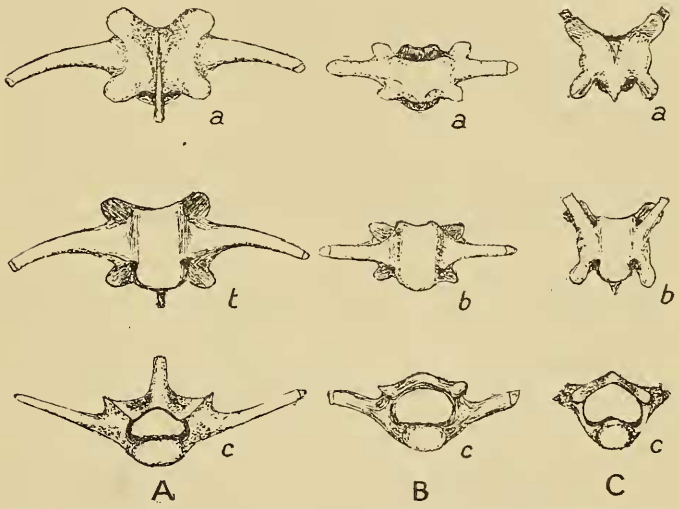
a.f.t., aperture for *filum terminale*; *c.*, coccyx; *ep.*, epiphysis; *f.*, flange upon the transverse process of the second vertebra, *II.t.p.*

It does not seem, however, that the occurrence of gaps between the neural arches in *R. temporaria* is to be attributed simply to a notching of the arches between the zygapophyses.

A comparison of the neural arch of a typical (*e. g.* sixth) vertebra of the grass-frog with that of the corresponding vertebra of *R. tigrina* or of *Pelobates fuscus*, will, I think, bear out this statement (text-fig. 2, A–C).

In all three cases it will be seen that there is an incisure upon the anterior face of the neural arch between the zygapophyses. In the Bull-frog and in *Pelobates* this incisure is a deep one, whereas in *R. temporaria* it is broad but comparatively shallow. Upon its posterior border the arch is practically not incised at all in *R. temporaria*, and is most deeply notched in *Pelobates*, the condition of *R. tigrina* being intermediate in this respect.

Text-figure 2.



The sixth vertebra of (A) *Rana tigrina* (× $\frac{3}{2}$), (B) *R. temporaria*, and (C) *Pelobates fuscus* (both × 3), to show the relative degree of incisure of the neural arches and the development of the neural spines in the three species. (*a*) Dorsal, (*b*) ventral, and (*c*) posterior view.

In *Pelobates* and in *R. tigrina*, however, *the centrum has practically the same length as the neural arch*, whereas in *R. temporaria* the centrum is, approximately, half as long again as the neural arch. When the vertebræ are articulated in the normal manner, therefore, the neural arches do not come into contact in this species, excepting at the zygapophyses, notwithstanding that some of the surplus length of the centrum has been absorbed in the concavity of the following centrum. In the case of *R. tigrina* (and *Pelobates*) the neural arch is sufficiently long to allow of considerable overlap upon the succeeding neural arch.

Neural spines, too, are well developed (text-figs. 1, 2). This

is especially marked in the anterior vertebræ of the column, where the hinder end of a neural spine may extend backwards upon the ensuing vertebra almost to the level of the notch between its post-zygapophyses (*cf.* text-fig. 1). Posteriorly the spines become shorter, though still well developed. Thus, upon the seventh vertebra the neural spine extends but little beyond the posterior margin of the neural arch ; in the eighth it is nearly vertical, and in the ninth the spine is slightly forwardly directed, so that its apex approaches very closely to that of the preceding vertebra. In this development of neural spines *R. tigrina* is remarkable, for of European Anura Boulenger has remarked : "Neural spines are absent or represented by a low keel, which is much prolonged posteriorly in *Discoglossus* and *Pelobates*" (op. cit. p. 38).

The intervertebral foramina in the Indian Bull-frog are, relatively, considerably smaller than are the corresponding nerve-exits in *R. temporaria*, and the column has, therefore, not at all the open-work structure which is so characteristic of our European frogs.

Moreover, the cartilaginous epiphyses found upon the distal ends of the transverse processes are particularly noticeable in *R. tigrina*. Upon the third vertebra (*cf.* text-fig. 1) these are very large indeed, and backwardly directed, recalling strongly the condition figured by Boulenger for *Pelobates fuscus* (op. cit. fig. 75).

The transverse processes also are, relatively, much longer than are the corresponding structures in *R. temporaria*, but in this respect the condition of *R. esculenta* is closer to that of the Indian species.

Apart from these generalities, there are notable differences to be observed in the second, eighth, and ninth vertebræ of the two species.

In the second vertebra of *R. tigrina* there is developed a very pronounced flange-like projection upon the anterior border of the transverse process (text-fig. 1, *f.*). This varies somewhat in size, but becomes very marked indeed in some specimens. It serves, apparently, for the attachment of the *Mm. intertransversarii capitis*, which have their insertion upon the base of the skull, slightly lateral to the condyles. The complete absence of this flange from the European Ranidæ is doubtless to be attributed to the much slighter development of these muscles in these more slightly built frogs.

In the eighth vertebra, the transverse processes are as long as, and rather stouter than, the diapophyses of the three preceding vertebræ. They are peculiar, in the normal vertebral column of *R. tigrina*, in that alone of all the transverse processes they are sloped slightly forwardly (*conf.* Howes, '02, fig. 35, with my text-fig. 1). The well-developed neural spine rises almost vertically.

In the ninth vertebra, the transverse processes should be described as slightly conical (with the base of the cone distal) rather than as cylindrical, which latter shape is said to be

characteristic of these structures in the Ranidæ. In some specimens I have observed a flattening even of the distal extremity of the diapophysis, which, too, is sometimes to be noticed in the immature *Rana temporaria*. The neural spine is somewhat variably developed, but is always represented by at least a slight elevation in the mid-dorsal line. From this a pair of distinct ridges diverge. These pass outwards and backwards onto the dorso-posterior face of the transverse processes, but fade out before reaching the distal end.

The coccyx, too, in *R. tigrina* differs from that of *R. temporaria* or of *R. esculenta* in that the paired foramina which, in these European species, permit of the exit of the tenth pair of spinal nerves are very frequently absent from the Indian species. When, however, they do occur, they are generally very minute indeed, and not uncommonly, upon one side or both, this external opening leads only into a blindly ending canal. As an infrequent variation, specimens are seen in which there may be two apertures upon one side. In such cases only the upper canal appears to have open communication with the vertebral canal. Such a condition is figured in my account of the Anuran coccyx ('**15**, fig. 1 *b*, x., xi.).

It is probable that we have here the last vestige of an aperture for the lost eleventh spinal nerve, such as is still found occasionally in the more primitive Anura.

From the foramen of the tenth nerve, when present, there runs backwards and upwards a slight groove which is often several millimetres in length.

Of a total of 32 coccyges examined, only four (12½ per cent.) showed *a pair of canals* for spinal x., and, of these, the openings in three were very small. In five other specimens a pair of extremely minute external apertures were found, but on neither side of three of these was there a clear passage for the finest hair. The remaining *two* permitted the passage of a very fine hair on one side only.

In *seven* other specimens a single aperture only was found, but in only two cases was I able to pass a hair into the vertebral canal. In the remaining five specimens the canal apparently ended blindly internally.

Thirteen coccyges (40 per cent.), including four specimens in which the vertebral column was abnormal in other ways, showed a complete absence of the foramina on both sides.

Three specimens exhibited two minute apertures on one side and a single aperture only upon the other. Of these, in one specimen all the canals ended blindly, and of the remaining two each had a single canal on that side upon which there were two apertures.

In the twelve asymmetrical cases the canal (or aperture) occurred in eight cases upon the right side and in four upon the left.

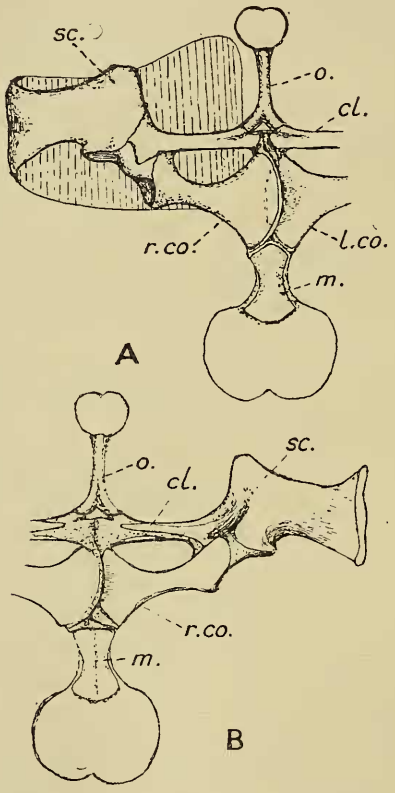
It is a little difficult to decide what is to be regarded as the normal condition of the coccyx in *R. tigrina*. It is probably

correct to say that in the great majority of the individuals of this species, the paired foramina for the tenth spinal nerves are absent or imperfect.

The Shoulder-Girdle and Sternum.

The shoulder-girdle of *R. tigrina* (text-fig. 3) is very stoutly built and, in general, resembles the condition of the corresponding structure in *R. esculenta*.

Text-figure 3.



The Shoulder-girdle and Sternum of *Rana tigrina* (nat. size).

(A) Ventral view, and (B) dorsal view. In the latter the supra-scapula is removed upon the right side.

cl., clavicle; *m.*, metasternum; *o.*, omosternum; *r.co.*, *l.co.*, right and left coracoids; *sc.*, scapula.

In one particular, however, viz., in the arrangement of the coracoids, it presents a condition which has not, I believe, been recorded in any of the Firmisternia.

The coracoids, while having the normal shape and transverse position, *do not meet in a median epicoracoidal cartilage but overlap each other in the middle line.* At first sight it appears that there is merely an uneven suture, such as is seen between the epicoracoid cartilages of an immature *Rana temporaria,* but a closer examination reveals the existence of a definite overlap (*cf.* text-fig. 3).

It differs from the overlap of the arciferous condition in that the epicoracoidal cartilage is completely calcified in the adult and that the coracoid comes, at its antero-mesial border, into contact with the clavicle upon the ventral surface. There is, I believe, synostosis between the two coracoids, for there appears to be no freedom of movement.

The direction of the overlap, in the specimen figured, resembles that prevailing in the Arcifera, the right coracoid lying ventral to the left, but the opposite condition is met with not infrequently *.

Dorsally the pre-coracoid cartilage is seen. It appears to be calcified, and separates, somewhat widely, the clavicle from the coracoid.

The bony style of the omosternum is also peculiar (amongst Ranidæ) in being bifid posteriorly. The diverging processes meet corresponding elevations upon the clavicles, and the small space between the three bones is filled, in life, by a delicate membrane.

The Tenth Spinal Nerve.

Correlated with the minute size, or the absence, of the foramina in the coccyx, the tenth pair of spinal nerves are, in *Rana tigrina*, either extremely delicate or, more often, altogether absent. When present, they seem invariably to pass dorsally from their exits, lying in that small groove in the coccyx, to which reference has been made. In this disposition, therefore, this nerve differs considerably from the corresponding structure in *R. temporaria*, in which it passes ventrally after leaving its foramen. In the Bull-frog the nerve, even if present, is hidden from view in a dissection made, in the usual manner, from the ventral surface. It never, in this species, I believe, makes any contribution to the sciatic plexus, nor have I been able to demonstrate any sympathetic ganglion related to it.

Literature.

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* Beddard ('11, p. 396) has pointed out that variation in this arrangement is also occasionally encountered in *Megalophrys fœa*.